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XVI.—*On the Origin of the Fauna of Celebes.*

By Professor Dr. Max Weber.

[The following notes * are part of an article by Dr. Max Weber entitled "Die Süsswasserfische des Indischen Archipels," which appeared in his 'Zoologische Ergebnisse einer Reise in Niederländisch Ost-Indien,' vol. iii. 1894. In the first and special portion of the article complete lists of the freshwater fishes of Celebes and other islands are given, which are not reproduced here.]

In dealing more closely with some questions of a general character, our starting-point is the opinion so clearly expressed by Dr. Günther † :—"The freshwater fishes being limited to the river- or lake-systems which they inhabit, and being less exposed to the disturbance affecting the terrestrial animals, are singularly adapted for the elucidation of the original geographical distribution of animals of the present creation."

* Translated by Miss Ethel S. Barton.

† Cat. Fish. viii. p. ix.

1. What Differences are exhibited between the Eastern and Western Portions of the Archipelago, as regards the Freshwater Fishes?

The comparison of Sumatra, Borneo, and Java, on the one hand, with Celebes, Flores, &c. (in short, those islands lying to the east of the larger ones), on the other, shows at once a marked falling off in the number of species of freshwater fishes.

One is, perhaps, at first inclined to explain this fact by the smaller size of the individual islands in the eastern, as compared with the western, portion of the Archipelago. The area of fresh water, both rivers and lakes, must, of course, from the nature of things, bear a certain proportion to the size of the island. The smaller island will possess, on the whole, a less developed and less extensive river-system, and thereby be less adapted for the formation of a rich fish-fauna. Further, the form of the island and the disposition of its mountains have a proportionate influence. A glance at the map shows, for instance, that Flores can possess only very small insignificant rivers, and that also in Java, or on the east [? west—*Translator*] coast of Sumatra, the rivers can attain to only a small degree of development.

The size and configuration of the island, with the concurrent formation of rivers and lakes, are factors which must be taken into account in considering the peculiarities of the interesting fish-fauna of fresh water. These present, however, no satisfactory explanation of the above-mentioned decrease in the number of species of freshwater fishes in the eastern portion of the Archipelago. This may be at once seen in the case of Celebes as compared with Java. Celebes has an area of 178,833 square kilom., while Java has 125,896 square kilom.; and the opportunities for the formation of a freshwater fauna under present conditions are no less favourable than in Java. As a proof of this I would point out the river-system of the Tjenrana, in the south-west peninsula of Celebes, concerning the extent of which there exist careful estimates by A. Wichmann *; and I myself was able to collect here more or less extensively. According to Wichmann, the river-system of the Tjenrana embraces an

* A. Wichmann, "Die Binnenseen von Celebes," in Petermann's Mitth. 1893, Heft. x., xi., and xii. Compare also A. Wichmann, "Bericht üb. eine Reise im Ind. Archipel," in Tijdschr. Koninklijk Nederlandsch Aardrijkskundig Genootschap, 1890, pp. 47–49, and idem, 1892, pp. 299, 300.

area of 6065 square kilom., since it takes up the rivers Lapa-Lupa (La-Palupa), called in its upper waters Walannaë, as well as the Minralang and others. To the Tjenrana system belong also the freshwater lakes Tempe and Sidenreng, the latter covering 65 square kilometres.

So extensive a river-system can but be conducive to the development of a freshwater fauna. When, notwithstanding, the freshwater fish-fauna of Celebes is poor in species (though not in individuals), then the cause must lie in some other direction. This has been already recognized by von Martens and, as we shall see later, by Günther.

It might be thought that the present conditions are only of comparatively recent date, and that formerly, from a different configuration of the island, the river-systems reached only a small degree of development. This brings us to a region outside purely zoological considerations, which we must nevertheless refer to later. At the same time emphasis must be laid on the fact that another difference exists, more important than the actual decrease in the number of species, between the east and west portions of the Archipelago.

This difference is most clearly to be seen by a comparison of tables showing the occurrence of such fish in the Indian Archipelago as are undoubtedly freshwater. The following figures give the number of species of the different families on the three large Sunda Islands, as well as on Celebes, Flores, and Timor. Billiton and Madura are included in this enumeration, as well as Bali, which must not be omitted.

	Sumatra.	Borneo.	Billiton.	Java.	Madura.	Bali.	Flores.	Timor.	Celebes.
Siluridæ	64	68	4	45	5	1	0	0	0
Cyprinidæ.....	84	83	4	63	0	2	0	0	0
Cyprinodontidæ*....	1	1	0	2	0	0	0	0	1
Osteoglossidæ	1	1	0	0	0	0	0	0	0
Nandidæ	3	3	2	1	0	0	0	0	0
Luciocephalidæ	1	1	1	0	0	0	0	0	0
Mastacembelidæ	5	5	1	3	0	0	0	0	0
Ophiocephalidæ	9	11	2	4 (5)	3	0	1	0	1
Labyrinthici.....	8	9	1	8	3	2	0	1	1 (2)

* The Cyprinodontidæ, although consisting largely of brackish-water forms, are here included under true freshwater fishes, since the genus *Haplochilus* belongs entirely to fresh water.

From this Table it may be seen that east of Borneo and Java the Mastacembelidæ, Siluridæ, Cyprinidæ, Nandidæ, Luciocephalidæ, and Osteoglossidæ are entirely wanting. In our earlier list of freshwater fishes existing in Celebes, the Siluride genera *Plotosus* and *Arius* were given. These were never found, however, in the interior, but only in the neighbourhood of river-estuaries; and, what is more important, they are equally at home in brackish water or in the sea. They do not therefore come under consideration here, where we are dealing exclusively with true freshwater fishes. Further, it is also worthy of notice that along the southern chain of the islands the transition is not so sudden as between Borneo and Celebes. The above Table shows us that already in Java the Luciocephalidæ, Nandidæ, and Osteoglossidæ are wanting, while Bali, so far as we know at present, only possesses two of the Cyprinidæ and one of the Siluridæ. Were we inclined to continue the boundary-line in the usual way between Bali and Lombok, that boundary-line which, for freshwater fishes also, almost completely separates Borneo from Celebes, we should have to bear in mind our complete ignorance of the freshwater fauna of Lombok. Supposing for the moment that the conditions in Lombok were the same as those in the more eastern islands—Sumbawa, Flores, &c.—this boundary-line would have little to mark off. At the best, so far as our present knowledge goes, there would be on the one side Bali, with two Cyprinidæ and one Siluridæ, while on the other—the eastern side—neither is represented. The difference, in itself unimportant, becomes still smaller when we examine how matters stand in Celebes as regards the Ophiocephalidæ and Labyrinthici, equally characteristic of the western portion of the Archipelago. Sumatra has nine, Borneo eleven, Java only four species of *Ophiocephalus*; not one is recorded from Bali; but Celebes, Flores, even Amboina still have *Ophiocephalus striatus*. This startling fact was recognized by Bleeker and v. Martens for Celebes and Amboina. v. Martens believed it was possible that this fish, characteristic of the Indian fauna, had been introduced by man; but against this is to be placed its widespread occurrence in Celebes, even in places where the population has not reached such an advanced state of civilization as to allow the probability of such an introduction. This objection holds good in a still more marked degree for Flores, where I also found this species in a small stream unsuitable for the cultivation of fish. Besides this, the inhabitants of Flores are of a low type and seldom fish. Finally, as regards the Labyrinthici, of the nine (or

eight) species recorded from Sumatra, Borneo, and Java, Bali possesses only two—*Osphromenus trichopterus* and *Anabas scandens*. The latter occurs on Sumbawa, Celebes, Rotti, Sumba, and Timor *, but in such a manner as to preclude the idea of introduction by man.

The question, therefore, as to the differences existing between the eastern and western portions of the archipelago as regards freshwater fishes may be answered thus :—

1. The transition from Borneo to Celebes in respect of river-fishes is very abrupt. Out of the nine families of freshwater fishes characteristic of the Oriental region only three occur in Celebes, each represented by one species, while, according to our present knowledge, Borneo has 182 species. The Cyprinidæ and freshwater Siluridæ, which are so well represented in Borneo, are entirely wanting. This want is not explained by the present hydrographical condition of Celebes.

2. Since Siluridæ (one species) and Cyprinidæ (two species) are found in Bali, and not in those islands further to the east (which fact would argue their non-occurrence in Lombok, hitherto unexplored ichthyologically), this would coincide with the original Wallace line. But it must not be forgotten that already in Java there is a decrease in freshwater fishes, not only with respect to the number of species in proportion to the smaller size of Java compared with Borneo and Sumatra, but also qualitatively, inasmuch as two families—the Osteoglossidæ and Luciocephalidæ—are wanting in Java. In Bali six out of the nine families given in our tables no longer occur †.

2. What is the Origin of the Freshwater Fish-fauna in the Eastern Portion of the Archipelago?

Since we have shown that the islands to the east of the great Sunda group are almost entirely wanting in true freshwater fishes, the question arises, What is the origin of the fish-fauna on these islands? An inspection of the tables for Celebes and Amboina, although dealing with a much richer material, gives the same result as Ed. v. Martens ‡

* According to Bleeker, Amboina has a peculiar form—*Anabas microcephalus*, Blkr.

† Probably, however, *Ophiocephalus striatus* and a species of *Haplochilus* occur in Bali.

‡ Ed. v. Martens, 'Preuss. Expedition nach Ost-Asien, Zoolog. Theil, Bd. i. 1874, p. 313.

arrived at in his excellent explanation of the fauna of the Indian Archipelago twenty years ago. This author writes:— "In Celebes begins a far greater poverty in freshwater fishes, inasmuch as from here onwards the true freshwater species are wanting throughout the whole eastern portion of the Archipelago. . . . . It is therefore principally those genera regarded above as consisting of migratory and brackish-water fishes, such as eels, several Percoidæ, and some Gobioidæ, which form the freshwater fauna in Celebes and the Moluccas, several species of which appear only to have been found in fresh water . . . . while the majority live also in the sea or at least in brackish water. . . . The very poor development of the freshwater fauna in the eastern half of the Archipelago arises partly from the fact that hardly anything but small rivers or streams exist, with stony bottom and varying depth; for Celebes, however, this explanation does not hold good, since the lake of Tondano, for instance, contains a considerable mass of water, in which Cyprinidæ and Siluridæ could feel quite at home. In the absence of these two families of freshwater fishes, the eastern portion of the Archipelago agrees with its eastern and southern neighbours, Australia and the small islands of the Pacific."

As I have said, my much richer material only confirms this statement. This may be shortly explained by the conditions offered by Celebes. I select this island advisedly, because it possesses the most favourable hydrographical conditions for the cultivation of a freshwater fauna, and also because this fauna is much richer on Celebes than on the other islands in the eastern portion of the Archipelago. Another point in selecting Celebes for consideration lies in the peculiar position which it occupies in many respects, and this accounts for the interest long shown in this island by many investigators.

The Table in the original memoir shows that Celebes has at least fifty species of fishes in true fresh water; the numerous other species given in the same Table, which up to the present have only been recorded from the river-estuaries, are not considered here. Of these fifty species there are only twenty-five which are not recorded also from the sea or brackish water; these are:—

Dules rupestris, *C. V.*
Therapon micranthus, *Blkr.*
Toxotes jaculator, *Pall.*
Gobius bicirrhosus, *M. Web.*
—— biocellatus, *C. V.*
—— grammepomus, *Blkr.*
Gobius lacrymosus, *Pet.*
Sicydium cynocephalum, *C. V.*
—— microcephalum, *Blkr.*
Platyptera aspro, *C. V.*
Agonostoma plicatile, *C. V.*
—— oxyrhynchum, *C. V.*

Ophiocephalus striatus, *Bl.*
Anabas scandens, *Dald.*
? —— oligolepis, *Blkr.*
Haplochilus celebensis, *M. Web.*
Hemiramphus orientalis, *M. Web.*
? Notopterus kapirat, *Lac.*
Monopterus javanensis, *Lac.*
Symbranchus bengalensis, *M'Clell.*
Anguilla mauritiana, *Benn.*
—— sidat, *Blkr.*
Ophichthys Kaupi, *Blkr.*
Doryichthys caudatus, *Pet.*
Tetrodon erythrotænia, *Blkr.*

This great poverty in the fish-fauna of fresh water in Celebes and its marine character cannot be explained by the present hydrographical condition of the island.

3. Has the Fish-fauna of Celebes an Australian Character?

In his invaluable 'Handbook of Ichthyology' Günther divides the equatorial zone, in respect to the distribution of freshwater fishes, into a Cyprinoid and an Acyprinoid region. In the Acyprinoid he includes the tropical American and tropical Pacific regions, characterizing the latter by the presence of Dipnoi, while, in contradistinction to the Indian region, the Cyprinidæ and Labyrinthici are absent. "This tropical Pacific region embraces all islands to the east of Wallace's line, New Guinea, Australia (with the exception of its south-eastern portion), and all islands in the tropical Pacific as far as the Sandwich group." The importance of Günther's views on this question is so great that we will quote further from him :—"Comparing the area of this region with that of the others, we find it to be not only the poorest in point of the number of its species generally, but also in that of the possession of peculiar forms." Then follows a short list, after which he says, "The paucity of freshwater fishes is due in the first place to the arid climate and the deficiency of water in the Australian continent, as well as to the insignificant size of the freshwater courses in the smaller islands. Still this cannot be the only cause; the large island of Celebes, which by its mountainous portions, as well as by its extensive plains and lowlands, would seem to offer a favourable variety of conditions for the development of a freshwater fauna, is, so far as has been ascertained, tenanted by seven species of freshwater fishes only, namely, two *Arius*, two *Plotosus*, one *Anabas*, one *Ophiocephalus*, and one *Monopterus*, all of which are the commonest species of the Indian region. . . . . Finding, then, that even those parts of this region which are favourable to the development of freshwater fishes have not produced any distinct forms, and that the few species which inhabit them are unchanged or but slightly

modified Indian species, we must conclude that the whole of this area has remained geologically isolated from the other regions of this zone since the commencement of the existence of Teleostei, and that, with the exception of *Ceratodus* and *Osteoglossum*, the immigration of the other species is of very recent date."

To this statement we may be permitted to add the following remarks:—Firstly, the fish-fauna of Celebes is somewhat different from what Günther was aware of at that time. This has been explained at length above. *Arius* and *Plotosus* are unquestionably forms which have wandered in from the sea, and belong only to the river-estuaries.

As touching the further agreement with the fish-fauna of Australia, I have drawn up, in answer to this question, a list of Australian fishes. Although this may be incomplete, it will nevertheless represent the character of this fish-fauna. Only those genera are given here which have been recorded from the tropical regions of Australia:—

Pseudolates.
Lates.
Psammoperca.
Serranus.
Mesoprion.
Ambassis.
Pseudambassis.
Edelia.
Acanthoperca.
Apogon.
Eleotris.
Aristeus.
Atherinichthys.
Mugil.
Agonostoma.
Myxis.
Chœrops.
Coris.
Pseudorhombus.
Synaptura.
Apogonichthys.
Gulliveria.
Oligorus.
Ctenolates.
Dules.
Therapon.
Pristipoma.
Gerres.
Toxotes.
Upenoides.
Chrysophrys.
Lethrinus.
Centropogon.
Polynemus.
Corvina.
Caranx.
Psettes.
Equula.
Sillago.
Gobius.
Gobiodon.
Periophthalmus.
Plagusia.
Plotosus.
Copidoglanis.
Cnidoglanis.
Eumeda.
Arius.
Haplochiton.
Saurida.
Galaxias.
Belone.
Osteoglossum.
Engraulis.
Chatoessus.
Brisbania.
Clupea.
Elops.
Megalops.
Anguilla.
Conger.
Muræna.
Ostracion.
Ceratodus.

From this list it may be seen that three elements go to form this fish-fauna:—

1. Marine immigrants, which belonged originally to the tropical Pacific, and could therefore penetrate into the rivers of all islands and countries washed by this ocean. They show nothing characteristic of the Australian fauna. Parallel or similar species are chiefly found in Australia and Celebes, for example, but they also occur in the rivers of the large

Sunda Islands. That they are, perhaps, less numerous in the latter locality I have already tried to explain by the fact that a given amount of water can only harbour a certain number of fishes. The western islands possess fishes peculiar to their rivers, and these are wanting in the eastern islands, where a more abundant immigration is rendered possible.

2. True freshwater fishes, which also belong to the Oriental region. We may cite *Dules*, *Haplochiton*, and, if we go further, *Toxotes*, *Gobius*, *Eleotris*, *Agonostoma*, *Anguilla*.

3. True freshwater fishes, which are absent from the Indian Archipelago, east of the "Wallace line." These are *Ceratodus*, *Osteoglossum*, *Oligorus*, *Galaxias*.

With the exception of *Osteoglossum*, which occurs in Borneo and Sumatra, it is just these fish characteristic of Australia that are absent both east and west of the "Wallace line." The similarity of the freshwater fishes of Australia and Celebes rests therefore on the following points:—

1. The Cyprinidæ, Mastacembelidæ, Nandoidæ, belonging to the Oriental region, are absent.

2. Siluridæ are represented only by marine immigrants.

3. Numerous marine forms inhabit the fresh water.

There are, however, considerable differences:—

1. *Ceratodus*, *Osteoglossum*, *Oligorus*, *Galaxias*, forms characteristic of Australia, are absent.

2. On the other hand, Celebes has certain genera belonging to the Indian region which are wanting in Australia—*Anabas*, *Ophiocephalus*, *Symbranchus*, *Monopterus*.

Opposed to these positive differences there remains a similarity in negative characters, which rests on an absence of a number of Indian forms in Celebes as well as in Australia. It may be expressed thus:—Australia and Celebes agree in poverty of freshwater fishes; Australia has some forms peculiar to itself which do not occur in Celebes; on the other hand, Celebes possesses some forms which belong to the Indian region and do not occur in Australia. Thus the character of the fish-fauna of Celebes is not Australian, but Indian, and that in a high degree impoverished.

4. How can the Fish-fauna of Celebes be explained?

From the foregoing statements it may be seen that the freshwater fauna of Celebes is principally recruited by immigration from the sea, and that only isolated representatives of true freshwater fishes (*Ophiocephalus striatus*, Bl., *Anabas scandens*, Dald., *Haplochilus celebensis*, M. Web., *Monopterus javanensis*, Lac., *Symbranchus bengalensis*, M'Clell.) are

found there. These belong to the Oriental region. Indigenous forms do not occur (for *Haplochilus celebensis* cannot be considered such), nor *Ceratodus* and *Osteoglossum*, which belong to the tropical region of Australia, the latter being found also in the great Sunda Islands. From this we receive the impression that the entire area of fresh water, poor in freshwater forms, was gradually peopled from the sea.

How is this dearth to be explained, since it is not occasioned by the present hydrographical condition of Celebes?

Further, how is the qualitative difference in the fish-fauna of Celebes to be explained as compared with that of the large Sunda Islands?

The answer to the first question would be that the present hydrographical conditions were not necessarily those of the past. There are geological proofs that the shape of Celebes was formerly different from what it is to-day, and we are indebted to A. Wichmann for this important information. He shows that South Celebes (which is of special importance to us, as containing the system of the Tjenrana River specially in question) consisted in the second half of the Tertiary period (Neogen) of a number of small separate portions, rising like islands above the surface of the sea *. "In consequence of the negative elevation, which began at the end of the Neogen and continues to this day, the island of South Celebes was uplifted to form a peninsula through junction with the central mass of the island, while at the same time the surrounding coral-islands were raised and the sandstone-beds in the east rose from the sea as eroded surfaces" †.

From a geological point of view it is also probable that the connexion between North and South Celebes is comparatively recent. In a former article ‡ I pointed out the peculiar differences in the mammalian fauna of North and South Celebes. In South Celebes *Paradoxurus Musschenbroekii*, Schl., *Babirussa alfurus*, Less., *Cynopithecus niger*, Desm., *Sciurus murinus*, Müll. & Schleg., *Sciurus rubriventer*, Müll. & Schleg., *Sciurus leucomus*, Müll. & Schleg., *Sciurus Prevosti*, Desm., which up to the present have only been recorded from North Celebes, are absent. On the other hand, *Macacus maurus*, Cuv., *Sciurus notatus*, Boddaert, *Sciurus Weberi*, Jentink, are peculiar to South Celebes.

* A. Wichmann, "Bericht üb. eine im Jahre 1888–89 ausgeführte Reise nach d. Ind. Archipel," Th. i. p. 74, in Tijdschr. v. h. Nederl. Aardrijkskdg. Genootschap, Jaargang 1890.

† A. Wichmann, "Die Binnenseen von Celebes," Peterm. Mitth. 1893, Heft. x., xi., and xii. p. 18 des sep. Abdruckes.

‡ Max Weber, Zoolog. Ergebnisse, Bd. i. 1890–91, pp. 103, 110, 113.

Here we are dealing in part with large mammals. This difference between North and South is all the more marked that the number of mammals of Celebes is in any case not large. Still more marked are the differences between the land-snails of North and South Celebes. According to the statements of Ed. v. Martens* only sixty-four species had been recorded up to 1891, and of these only two are common to North and South, "namely *Trochomorpha planorbis*, which is distributed over the other large islands, and *Amphidromus perversus*, which occurs in Borneo; as a third there may perhaps be reckoned *Nanina limbifera*, which is, of course, characteristic of Celebes. . . ." Twenty-seven species are so far exclusively peculiar to the northern peninsula and thirty-one to the south-west. Three species are recorded only from the south-east peninsula and two species from both southern peninsulas. This interesting and remarkable difference in the fauna can be explained only by a former separation of the two regions. The junction of these regions since the Neogen period could not have sufficed to counteract the difference as regards the sluggish land-snails, which are not easily transported, and this difference is still evident among active mammals. Even among birds it is not yet eliminated. But it can hardly hold good for the freshwater fishes, since these are all of marine origin, and being equally distributed by the sea can penetrate into the most different river-systems.

If now, both from zoological and geological standpoints, important reasons exist for the acceptance of the theory that Celebes consisted formerly of several unconnected islands; if, further, geology makes it probable that this was the case during the second half of the Tertiary period; then it follows that the present rivers are of recent date, and the small size of the islands previously prohibited the formation of river-systems of any considerable size. Thus we see that the group which we now call Celebes was, in the second half of the Tertiary period, altogether unfitted for the production of a fauna of freshwater fishes. This would seem to me to explain the peculiarities of the fish-fauna of Celebes more satisfactorily than the theory that Celebes was separated from the Indian continent before it could have been peopled with Cyprinidæ and Siluridæ, for the simple reason that these genera had not yet appeared on the earth. This, however, seems to be Günther's view, if I am not mistaken. As we see, in his statement quoted above at length, he ends with the

* E. von Martens, "Landschnecken des Indischen Archipels," in Max Weber, Zoolog. Ergebnisse &c. Bd. ii. 1892, p. 259. An error has slipped in among the numbers of the species in North and South Celebes.

words "we must conclude that the whole of this area (the tropical Pacific region) has remained geologically isolated from the other regions of this zone since the commencement of the existence of Teleostei." As a zoologist one will readily agree with the view of this distinguished ichthyologist that Australia was at one time separated from Asia, when the Teleostei first appeared, so that only one of the oldest types—*Osteoglossum*—could occur there and in the Malay Archipelago. But for Celebes, according to the present state of our knowledge, such an explanation no longer seems to be correct.

The separation of Celebes from the Asiatic continent can only have taken place after the immigration of *Anoa depressicornis*, *Babirussa alfurus*, *Cynopithecus niger*, *Macacus maurus*, *Paradoxurus*, *Sciurus*, *Tarsius*, and other Indian forms. Even if the preservation of single species among these (*Anoa*, *Babirussa*, *Cynopithecus*, *Macacus maurus*) as solitary specimens in Celebes is taken as a sign of their great age, they still cannot be older than Siluridæ and Cyprinidæ. If, notwithstanding, the Indian river-fishes did not take part in the immigration of the Indian mammals, then it was probably because the hydrographical condition did not favour such immigration. It must also be remembered that in those early Tertiary times Cyprinidæ and Siluridæ had not yet such a wealth of species as has since been developed.

We grant therefore to Celebes a longer connexion with the Asiatic continent than was allotted to Australia. The poverty in freshwater fishes in Australia and Celebes has a different cause. Australia was separated from the Asiatic continent as far back as the first appearance of Teleostei; Celebes, on the other hand, was separated later, when Cyprinidæ and Siluridæ had already appeared, though still sparingly. In consequence of its splitting up into small islands it did not, however, offer the hydrographical conditions necessary for the reception and development of a freshwater fauna.

If my investigations have become more and more concentrated on Celebes, this has arisen because the fauna of Celebes has already been so often a subject of discussion, and because Celebes is in many respects a prototype of the other eastern islands. This does not mean that the conditions are exactly the same for Flores, Timor, and Amboina as for Celebes. On the contrary, the age of these islands is entirely different, as also their fauna; but for the fish-fauna of the above-named islands the same conditions obtain, except that Celebes has always the advantage of a greater area of fresh water.

As regards the fish-fauna, we came to the conclusion that

that of Celebes has an impoverished Indian, not an Australian, character. This, in the main, is also to be seen throughout the other animal groups in Celebes, where the Australian character is very slightly perceptible.

Land-molluscs are, of course, very important in questions of zoogeography. We therefore refer to the very clear statement of E. v. Martens*, who is probably the greatest authority on this subject. We will only quote the following:—"The land-snails of Borneo and those of Celebes are still sufficiently dissimilar, notwithstanding two species in common, to allow of the boundary-line being drawn here; but North Celebes is not easily separated as regards its land-snails from the Philippines, which are, however, placed by Wallace on the Indian side. Rather less startling is the difference between Java on the one side and Flores and Timor on the other; the special novelty characteristic of the East—the *Xesta* group of Naninæ—is found on the island of Bali, which Wallace places on the Indian side. Finally, as regards land-snails there is absolutely no unity between Celebes, the Moluccas, Flores, Timor, New Guinea, Australia, and the countless islands of the Pacific; no single genus or subgenus of land-snails is common only to these and unrepresented in other parts of the world; even the Moluccas on the one hand and Flores and Timor on the other are more dissimilar than Sumatra, Borneo, and Java. . . . ."

If we turn to the mammals, which play a prominent part in such questions, we find that here also the "Australian character" of Celebes rests only on the inaccurate knowledge of actual conditions possessed by authors who have given expression to the above view. The unhappy "Wallace line," which Wallace himself did not retain for Celebes, has penetrated as something fascinatingly simple into the brains of numerous zoologists. Text-books, which dismiss zoogeography with a few words, do not allow this classical line of demarcation to escape them. Thus the "Australian" fauna of Celebes continues to exist in spite of various protests †.

* E. v. Martens, in Max Weber, Zool. Ergebnisse, Bd. ii. 1892, p. 263.

† To name only a few writers who have expressed themselves according to this view, we may indicate E. Hæckel, "Zur Phylogenie d. austral. Fauna," in Semon, Zoolog. Forschungsreisen in Australien u. d. Malayischen Archipel (Jena, 1893). We read there:—"At no other point on the earth are there found two neighbouring faunal regions in such marked contrast as on the narrow boundary between the Indo-Malay and Austral-Malay region. If we traverse the narrow strait at the south end of this boundary-line—the deep Lombok Strait—we step at once out of the present into Mesozoic times. Although the two neighbouring islands,

If we exclude the Chiroptera, Celebes has the following land-mammals:—

Cynopithecus niger, *Desm.*
Macacus maurus, *F. Cuv.*
Cerocebus cynomolgus, *Schreb.*
Tarsius fuscomanus, *Fisch.*
Sciurus murinus, *Müll. & Schl.*
—— rubiventer, *Müll. & Schl.*
—— leucomus, *Müll. & Schl.*
—— Prevosti, *Desm.*
—— notatus, *Bodd.*
—— Weberi, *Jent.*
Acanthion javanicum, *F. Cuv.*
Mus Beccarii, *Jent.*
—— Musschenbroekii, *Jent.*
—— xanthurus, *Gray.*
—— Hellwaldii, *Jent.*
—— callithrichus, *Jent.*
Mus Meyeri, *Jent.*
—— Faberi, *Jent.*
—— decumanus, *Pall.*
—— rattus, *L.*
—— celebensis, *Gray.*
Echiotrix leucura, *Gray.*
Paradoxurus Musschenbroekii, *Schl.*
Viverra tangalunga, *Gray.*
Anoa depressicornis, *Smith.*
Sus celebensis, *Müll.*
Babirussa alfurus, *Less.*
Russa russa, *Müll.*
Phalanger celebensis, *Gray.*
—— ursinus, *Temm.*

If we include the island of Sanghi, in very close proximity to Celebes, as well as the Saleyer group, there are the following additions:—

Sciurus Rosenbergi, *Jent.*
Paradoxurus musanga, *Gray.*
Phalanger maculatus, *St.-Hil.*

Bali and Lombok, are only a few miles apart, and are subject to the same climatic conditions, the land-fauna characteristic of each is quite different; and still more is this the case when we cross the Macassar Strait from the Indian Borneo to the Australian Celebes. The decided contrast in the birds and mammals of each is so great that it must be reckoned as one of the most striking chorological arguments of Transformismus" ("schlagendsten chorologischen Argumenten des Transformismus"). Hæckel ('Schöpfung der Thier,' 1893, p. 238) is of the same opinion, and does his utmost to make the mammal-fauna of Celebes "and those islands which together with it form a group" an Australian one. The stag and the civet-cat were introduced by man into Celebes, perhaps also the pig (*Sus celebensis*); "it may, of course, have had an opportunity of swimming across the arms of the sea and of developing in Celebes into a peculiar species, while the squirrels and the Tarsii have possibly also reached Celebes on drift-wood . . . the crested baboon, the Indian hog, and the Anoa, probably ancient forms, which Celebes obtained when it was still connected with the Indian region, thereby offering opportunity for the immigration of certain animals which have since died out in India." Thus, while some Indian mammals have been imported, and *Sus celebensis*, six species of squirrels, and *Tarsius fuscomanus* have either swum or been drifted across, and the mice (of which there are about twelve species unconnected with Australian mice) "are descendants of former Australian species," there remain three species of Phalanger, the only animals, as the author himself confesses, peculiar to the Australian region. One asks with astonishment why Phalangers did not come to Celebes on drift-wood, since they are splendid climbers, can cling tightly to trees, and are very tenacious of life. Still more astonishing is it that an author who writes about Celebes should know so little of its fauna that he quite forgets two apes (*Cercocebus cynomolgus* and *Macacus maurus*) and two beasts of prey (*Paradoxurus musanga* and *P. Musschenbroekii*). These probably wandered over from India too when Celebes "was united to the Indian region."

According to this, the so-called Australian element consists of only three species, all belonging to the genus *Phalanger* (*Cuscus*), as opposed to thirty-one non-flying land-mammals, which unquestionably belong to the Oriental region. This genus *Phalanger*, of which only five species are known, has only one representative in Australia. The above conclusion therefore holds good for the Celebes mammal-fauna, namely, that it presents principally an impoverished Indian character. This fact, and the preservation in Celebes of certain ancient forms, indicate that the connexion with the Indian continent was much earlier severed than was the case with the large Sunda Islands.

But also in the southern chain of islands of the Archipelago the conditions are other than Hæckel believed when he maintained, probably relying on Wallace, that in passing from Bali to Lombok one steps out of an Indian fauna into Mesozoic times. One simply enters an impoverished Indian fauna, which impoverishment has already begun in Bali, as I have shown above, in dealing with the fishes. Since the land-molluscs have been already mentioned, I may add some remarks on the mammals. Some years ago Jentink * rightly pointed out that Wallace's statement—"Bali and Lombok differ far more from each other in their birds and quadrupeds than do England and Japan"—is entirely incorrect as regards mammals. Hardly anything is known of either island, except that on Lombok occur *Cercocebus cynomolgus*, Schreb., and *Tarsius spectrum*. In Flores, still further east, I have proved the occurrence of *Cercocebus cynomolgus*, Schreb., *Paradoxurus musanga*, Hodgs., *Mus decumanus*, Pall., *Mus d'Armandvillei*, Jent., *Mus Wichmanni*, Jent., *Acanthion javanicum*, Cuv., *Sus vittatus*, Müll., *Russa russa*, Müll.†

These are exclusively Indian forms. This Indian fauna is enriched if we note that *Tarsius fuscomanus*, Fisch., is recorded from the island of Savu (between Timor and Sunda), and a species of wild cat (*Felis megalotis*, Müll.) from Timor and Rotti. Altogether the mammal-fauna of Timor contains only one species which is not Indian, viz. a single species of *Phalanger*, all the rest belonging to the Oriental region.

The original boundary-line, as drawn by Wallace, therefore divides island-groups from each other, of which the western ones (Borneo, Sunda, and Java) have received a rich Oriental fauna, and have been able to evolve specific forms of an Indian character. This has arisen partly from their

* Jentink, in Tijdschr. v. h. Kon. Nederl. Aardrijkskundig Genootschap, 1889 (meer uitgebr. artikelen).

† Zool. Ergebnisse, Bd. iii. 1893, p. 260 *et seq.*

size, but principally through a prolonged connexion with the Indian continent.

Of those islands east of the boundary-line, Celebes was first cut off from the Indian mainland, and from that time has so remained. Hence it retained isolated ancient forms, which developed independently. Since it consisted from an early date of separate small islands, the fauna remained poor.

As regards the southern chain of islands (Bali, Lombok, Sumbawa, Flores, Timor, &c.), the impoverishment of the Indian fauna begins even in Bali. A sharp boundary between Bali and Lombok, which would have to rest on the evidence of various groups of animals, does not exist. Marsupials appear first in Timor, represented by one species of *Phalanger*. The above-mentioned southern chain of islands is therefore a zoogeographical representative of an earlier Java. To compare this chain with Celebes alone is inadmissible on account of the difference in their ages.

East of Celebes and Flores we come for the first time into a distinct transition region, where the Indian forms gradually retire and the Australian increase in number the further eastwards we go.

XVII.—*A Re-examination of Hutton's Types of New Zealand Earthworms.* By W. Blaxland Benham, D.Sc., M.A., Professor of Biology, University of Otago, Dunedin, New Zealand.

Captain Hutton's account of New Zealand earthworms was written some twenty years ago *, when the study of earthworms was only just engaging the attention of Perrier, and at a time when even the specific characters of the common British earthworms were absolutely neglected by English zoologists, in spite of the careful accounts by Dugès, at a time when there was practically no literature dealing with exotic genera except the papers which are buried in periodicals which were to be found only in the larger libraries; it is not surprising, therefore, that the descriptions should be vague, imperfect, and almost useless. Those of us who have made a study of earthworms have long recognized that Hutton's genera, in which he places the species, are

* "On the New Zealand Earthworms in the Otago Museum," Trans. New Zealand Institute, vol. ix. 1876, p. 350.